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Comparing preoperative dating and postoperative dating for second-trimester surgical abortions☆

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ABSTRACT

Objectives: To assess relationships between preoperative and postoperative dating of second-trimester surgical abortion.

Study design: We used a deidentified institutional database to extract demographic, dating and pathology data for surgical abortions performed at 14 to 23-6/7 weeks' gestational age (GA) from 9/2015 to 5/2017. We excluded women with multiple gestations, fetal anomalies and missing fetal biometric measurements. We assigned preoperative GA by ultrasonography for unknown last menstrual period (LMP) or when discrepancy between sonographic and LMP dating exceeded 7 days (<15-6/7 weeks), 10 days (16 to 21-6/7 weeks) or 14 days (22 to 23-6/7 weeks). We determined postoperative GA using fetal foot length pathology standards published by Streeter in 1920 and Drey et al. in 2005. We performed regression analysis to estimate the relationship between pre- and postoperative estimates of GA and to assess demographic effects on these estimates, and χ^2 tests to assess whether fetal foot lengths were concordant with, larger than or smaller than the expected range for the preoperative GA.

Results: The 469 patients analyzed had a median preoperative GA of 19-4/7 weeks (range 14-0/7 to 23-6/7 weeks). Preoperative dating highly correlated with postoperative dating using both pathology standards (r^2=0.95, p<.001), without any clinically relevant effect by body mass index (Streeter and Drey, p=.79), parity (Streeter p=.89; Drey p=.71), race (Streeter p=.06; Drey p=.07) or GA. Fetal foot lengths were larger than expected in 134 (28.6%) women using Streeter and 17 (3.6%) women using Drey standards (p<.001).

Conclusions: Preoperative dating and postoperative dating for second-trimester surgical abortion highly correlate. Use of Streeter standards results in more women with a postoperative GA greater than expected compared to Drey standards.

Implications: Increasing legal gestational age restrictions have placed additional burden on clinicians providing safe abortions, but guidelines on gestational age determination are lacking. Contemporary pathology standards consistent with modern practice and universally accepted by abortion providers and gynecologic pathologists are critical to our goal of safe and legal abortion provision.

1. Introduction

Determining the gestational age (GA) of a pregnancy is key in ascertaining if and how an abortion can be performed. Accurate GA estimation allows surgeons to plan appropriate cervical preparation and dilation to reduce complications [1,2] and ensures that surgeons practice within the gestational age restrictions of their institutions and local laws [3].

GA may be estimated using last menstrual period (LMP), ultrasonography [4] or a combination of both [5]. Clinicians frequently use sonographic fetal biparietal diameter (BPD) to estimate GA prior to second-trimester abortions [6]. Postoperative GA assessments commonly use standardized fetal foot length measurements, originally described by Streeter [7] in 1920 based on LMP and most recently by Drey and colleagues [8] in 2005 based on modeling using LMP and ultrasonography.

We aimed to estimate the relationships between preoperative GA and postoperative GA, to estimate the effect of patient demographics on the correlation between preoperative and postoperative dating,

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and to compare the effect of different pathology standards on postoperative dating.

2. Materials and methods

We utilized a quality improvement database created from the electronic medical records of women who had surgical abortions performed in the second trimester (14 to 23-6/7 weeks by preoperative GA as described below) at the University of California, Davis Medical Center (UCDMC) from September 2015 to May 2017. The University of California, Davis Institutional Review Board determined this study as exempt. The database only included women who did not have any of the following: a multiple gestation, known genetic or anatomic fetal anomalies, unreported sonographic BPD measurement, unreported fetal foot length measurement, missing demographic information or a dating ultrasound performed at a non-UCDMC facility. We did not enter any subsequent abortion procedure for the same patient occurring in the evaluation period into the database, which we deidentified for this study analysis. The database included patient demographics of body mass index (BMI), race and parity, and sonographic and pathology measurements from the electronic health records; we did not contact either patients or clinicians for any missing information. We assessed the total number of unique patients and second-trimester abortions performed at our institution using billing records.

All included patients received an ultrasound for confirmation of their pregnancy dating by LMP or to establish dating in the setting of an unknown LMP. For patients with a history of a prior cesarean delivery or other risk factors for abnormal placentation, a UCDMC radiologist performed a formal ultrasound evaluation prior to their preoperative visit. The radiologist used composite biometry measurements including BPD, head circumference, abdominal circumference and femur length to determine GA. We assessed all other patients in-office using a portable bedside ultrasound (Fujifilm Sonosite M-Tubo Ultrasound System 2014, Bothell, WA, USA) with a 3.5-mHz linear-array transducer, performed or supervised by one of five fellowship-trained family planning attending physicians. For women who had both formal and in-office sonography performed, we established sonographic dating by the formal ultrasound assessment.

In our standard practice, we measured BPD from the outer to inner margin of the fetal skull at the level of the falx, cavum septum, pellucidum, third ventricle and thalamic nuclei [9] to calculate a sonographic GA based on Hadlock's criteria [10]. We assigned preoperative GA based on LMP, or sonographic dating in cases of unknown LMP or when the discrepancy between sonographic and LMP dating exceeded 7 days (<15-6/7 weeks' GA), 10 days (16 to 21-6/7 weeks' GA) or 14 days (22 to 23-6/7 weeks' GA) [5]. Surgeons sent the pathology specimen for each case fixed in formalin. Pathologists assessed a postoperative GA within 7 days of fixation by measuring an intact fetal foot from heel to big toe, with mild pressure to gently flatten the foot, and then comparing that measurement to Streeter reference ranges [7], the favored reference by the pathology department at our institution.

For the analysis, we first compared preoperative and postoperative dating for each subject using the fetal foot length pathology parameters outlined by Streeter [7] (referred to hereafter as "Streeter standards") and Drey et al. [8], the most recent published reference (referred to hereafter as "Drey standards"). The Streeter standards are derived from the range of measurements from his population of women whose gestations were dated by LMP at the time of fetal expulsion, with outliers (as based on gross examination) discarded. The mean foot length in this reference is the average between the maximum and minimum fetal foot length measured for the particular GA. The Drey standards are modeled from their population of women seeking abortions and provides a midpoint and 1 SD range of the fetal foot length corresponding to a specific "best estimate" GA; the investigators determined this "best estimate" GA by LMP if the LMP-derived gestation was within 1 SD from the sonographic GA based on ultrasound growth charts [11]. We assigned a postoperative GA assessment according to each pathology standard by matching each subject's fetal foot length to the closest mean fetal foot length on Streeter's published measurement table [7] and the closest calculated midpoint foot length in the Drey model [8]. We also evaluated whether the measured fetal foot length was concordant with, larger than or smaller than the expected fetal foot length range for Streeter and Drey standards.

We performed χ^2 testing to assess the proportions of fetal foot lengths concordant with, larger than or smaller than the expected range for the preoperative GA based on Streeter [7] and Drey [8] standards. We assessed the relationship between preoperative estimates and both pathology standards using linear regression, and assessed effects of BMI, race and parity. Among patients whose final preoperative GA dating was determined by sonography, we compared the accuracy of in-office BPD ultrasound versus formal composite ultrasound according to each pathology standard using a test of independent proportions. We performed statistical analyses using SAS 9.4 (SAS Institute Inc., Cary, NC, USA), considering $p<.05$ as significant.

3. Results

We performed 724 second-trimester surgical abortions for 660 unique patients during the 20-month evaluation period. Our database contained 469 patients, whose characteristics are presented in Table 1.

Preoperative GA highly correlated with postoperative GA as determined by both Streeter and Drey standards ($R^2>0.95$, $p<.001$ for both), which was consistent (homogeneous) across advancing gestational age (Fig. 1). In regression analyses, we found no evidence of effects due to BMI category ($p=.79$ for both) or parity (Streeter $p=.89$, Drey $p=.71$) and weak evidence of clinically nonrelevant differences due to race (differences of 2 days or less; Streeter $p=.06$, Drey $p=.07$). Preoperative GA tended to overestimate postoperative GA by 1.4 days

Table 1
Characteristics of women undergoing second-trimester surgical abortions ($N=469$)*[a]

Characteristic	*n* (%) or median (range)
Age (years)	26 (13, 45)
Gestational age (weeks)[a]	19 4/7 (14–0/7, 23-6/7)
BMI (kg/m^2)	
Underweight (<18.5)	8 (1.7)
Normal (18.5–24.9)	154 (32.8)
Overweight (25–29.9)	130 (27.7)
Obese (30–39.9)	139 (29.6)
Morbidly obese (≥40)	38 (8.1)
Race	
White	158 (33.6)
African American	121 (25.8)
Latina	110 (23.5)
Asian American/Pacific Islander	27 (5.8)
Native American/Alaskan Native	43 (9.2)
Other	10 (2.1)
Parity	
0	140 (29.8)
1	126 (26.9)
2	95 (20.3)
3–4	87 (18.6)
≥5	21 (4.5)
Ultrasound examination location	
In clinic	377 (80.3)
Formal radiologic	92 (19.7)
Final dating modality[a]	
LMP	102 (21.8)
Sonography due to unknown LMP	265 (56.4)
Sonography due to discrepant LMP	102 (21.8)

LMP, last menstrual period; GA, gestational age

[a] Preoperative gestational age dating is based on LMP or sonographic dating in cases of unknown LMP or when the discrepancy between sonographic and LMP dating exceeded 7 days (<15-6/7 weeks' GA), 10 days (16 to 21-6/7 weeks' GA) or 14 days (22 to 23-6/7 weeks' GA) [5].

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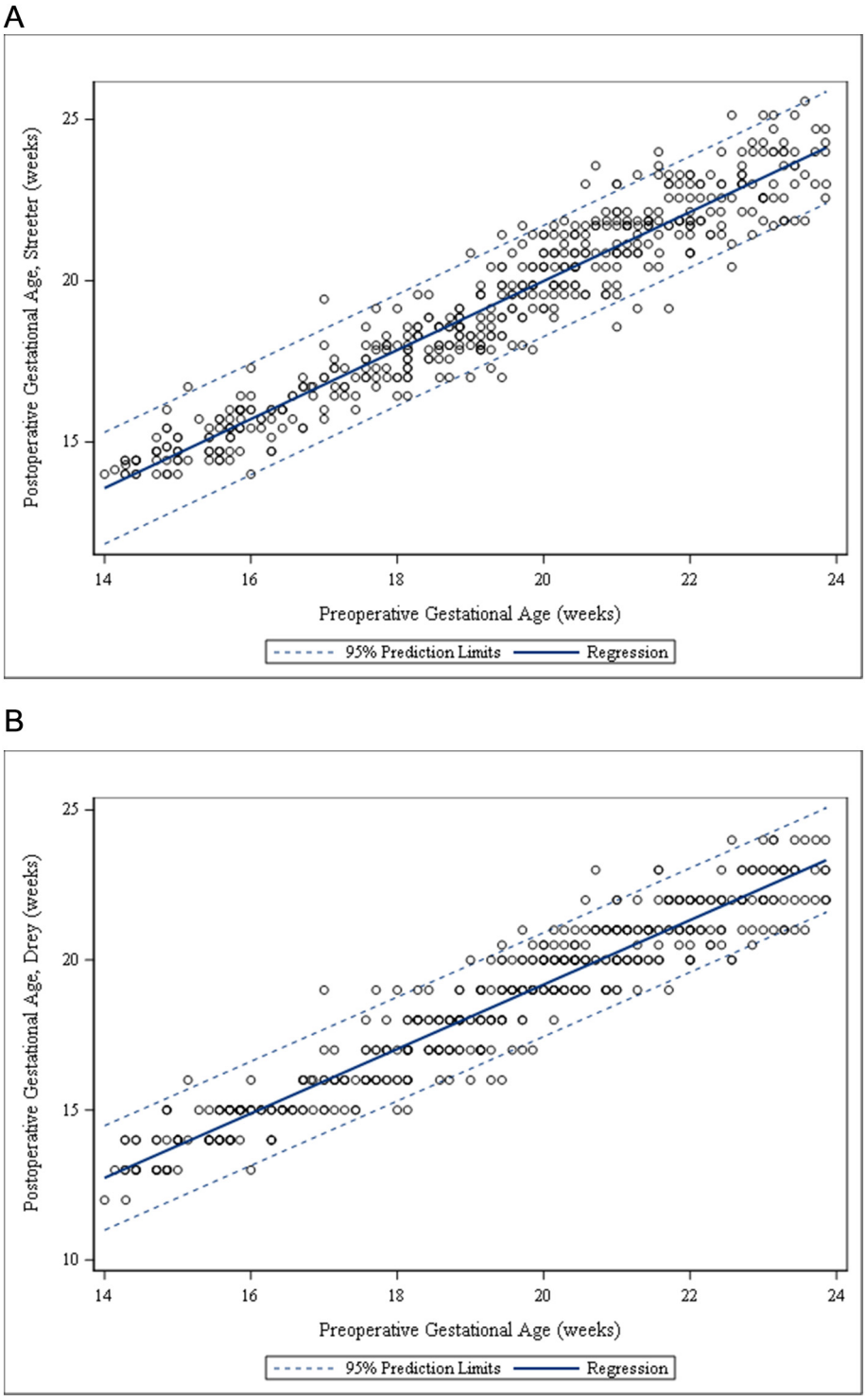

Fig. 1. Scatterplot comparing gestational age by preoperative and postoperative assessments in women undergoing second-trimester surgical abortion. (A) Streeter pathology standards [7]. (B) Drey pathology standards [8]. Fetal age by preoperative gestational age (weeks) versus postoperative gestational age (weeks), R^2=0.95, p<.001 for both graphs. Preoperative gestational age was based on LMP or sonographic dating in cases of unknown LMP or when the discrepancy between sonographic and LMP dating exceeded 7 days (<15-6/7 weeks' GA), 10 days (16 to 21-6/7 weeks' GA) or 14 days (22 to 23-6/7 weeks' GA) [5].

(intercept p<.001) on average using Streeter standards and by 2.3 days (intercept p<.001) using Drey standards.

Using Streeter standards, 200 (42.6%) women had a fetal foot length that fell outside the expected range for their preoperative GA, with 134 (28.6%) women exceeding and 66 (14.0%) smaller than the range expected for their preoperative GA (Table 2). Of the entire sample, 12 (2.6%) women (two at 22 to 22-6/7 weeks, nine at 23 to 23-6/7 weeks by preoperative dating) had fetal foot lengths larger than 45.5 mm (median 47 mm, range 46–49 mm), hich is the maximum fetal foot length described by Streeter for the end of 23 weeks' GA.

Using Drey standards, 99 (20%) women had a fetal foot length that fell outside the expected range for their preoperative

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Table 2
Relation of measured to expected fetal foot length using Streeter pathology standards in women undergoing second-trimester surgical abortion[a] [7]a, b

Preoperative GA (weeks)[b]	Number	Smaller	Concordant	Larger
14 to 17-6/7	139	27 (19.5)	79 (56.8)	33 (23.7)
18 to 18-6/7	56	10 (17.8)	24 (42.9)	22 (39.3)
19 to 19-6/7	62	20 (32.2)	30 (48.4)	12 (19.4)
20 to 20-6/7	64	1 (1.6)	42 (65.6)	21 (32.8)
21 to 21-6/7	62	3 (4.8)	29 (46.8)	30 (48.4)
22 to 22-6/7	47	4 (8.5)	37 (78.7)	6 (12.8)
23 to 23-6/7	39	1 (2.6)	28 (71.8)	10 (25.6)
Total	469	66 (14.0)	269 (57.4)	134 (28.6)

All data presented as *n* (%).

[a] Streeter defines a minimum and maximum foot length for each gestational age week. "Concordant" indicates patients whose measured fetal foot length fell between the minimum and maximum lengths for that GA week, "larger" are those whose foot lengths were larger than the maximum, and "smaller" are those whose fetal foot lengths were smaller than the minimum.

[b] Preoperative gestational age was based on LMP or sonographic dating in cases of unknown LMP or when the discrepancy between sonographic and LMP dating exceeded 7 days (< 15-6/7 weeks' GA), 10 days (16 to 21-6/7 weeks' GA) or 14 days (22 to 23-6/7 weeks' GA) [5].

GA, with 17 (3.6%) women exceeding and 82 (17.5%) smaller than the range plus 1 SD expected for their preoperative GA (Table 3). All patients in the sample had a fetal foot length that was smaller or equal to 49 mm, which is the Drey model's maximum fetal foot length plus 1 SD for gestations 23 to <24 weeks. Fewer patients fell out of their expected range according to Drey standards than Streeter standards ($p<.001$).

We compared accuracy of BPD by in-office ultrasound versus composite measurements by formal ultrasound and found limited evidence that composite ultrasounds may better correlate with postoperative GA compared to BPD ultrasounds using Drey standards [Drey standards: 236 of 295 (80%) BPD ultrasounds versus 63 of 72 (88%) composite ultrasounds, $p=.07$; Streeter standards: 175 of 295 (59%) BPD ultrasounds versus 47 of 72 (65%) composite ultrasounds, $p=.18$].

4. Discussion

Our data show that the choice of fetal foot length standard greatly affects the proportion of women whose pathology evaluation indicates a GA larger than expected, although preoperative GA and postoperative GA highly correlate with both Streeter and Drey standards. While race and ethnicity can cause variation in birth weight [12] and obesity can cause greater error in ultrasound GA estimation [13], we found no evidence that race, parity or BMI category had a clinically important effect on the correlation between pre- and postoperative GA, which is consistent with other previously published work [8,14–17]. Despite our best preoperative dating methodology to support surgical planning and intent to perform an abortion at a specific GA, a small proportion fell outside of that GA according to postoperative dating. One source of the discrepancy may be ultrasonography experience: formal composite preoperative dating trended towards better correlation with postoperative GA using Drey standards than in-office BPD-only dating. In an academic setting, inclusion of student, resident and fellow physicians who are learning to perform dating ultrasounds may diminish accuracy of our in-office dating ultrasounds despite supervision.

Our study also highlights the importance of understanding the generalizability of an established standard and how it may apply to a particular population. Pathology fetal foot length standards are typically used as categories, by which GA in weeks is affirmed if the fetal foot length is concordant with the expected measurement range for the preoperative GA. While the majority (78.9%) of patients in our sample had a fetal foot length that was concordant with their preoperative GA by Drey standards, a smaller proportion (57.4%) of patients had a fetal foot length that was concordant with their preoperative GA using Streeter standards. The discrepancy between standards becomes problematic in situations in which GA determination is important to the legal limitations of abortion provision. If we focus solely on those patients whose postoperative GA exceeded their preoperative GA, 3.6% of women exceeded their preoperative GA based on Drey standards compared with 28.6% based on Streeter standards ($p<.001$). Using Drey standards, no woman was postoperatively dated beyond 24 weeks based on fetal foot length, whereas 2.6% were beyond 24 weeks based on fetal foot length according to Streeter.

Streeter published his fetal foot length description in 1920 based on fetuses that were dated using menstrual age alone. However, current medical standards support pregnancy dating by ultrasound or by a "best estimate" of LMP verified by ultrasound over dating by LMP alone [5], consistent with the dating methodology used by Drey et al. [8]. Beyond changes in recommendations on how to estimate gestational age, the changes in patient characteristics, environment and general medical practices over the nearly 100 years since Streeter published his findings likely contribute to the inconsistency. Further, Streeter did not have access to statistical techniques that would allow confidence interval calculation [18], and he did not report standard deviations. For comparison, Drey et al. [8] included both a fetal foot length range generated from their population and a range including 1 SD to account for population variability. Streeter also performed fetal measurements after 2 weeks of formalin fixation as compared to Drey's fresh specimens. Streeter pointed out in his report that formalin often leads to initial tense distention due to osmosis [7]. Our pathologists process surgical specimens within 7 days per institutional policy, so these measurements are likely not to correlate well with Streeter standards.

Because we extracted our data from a quality assurance database, we do not have a comprehensive description of our patient population obtaining a second-trimester abortion procedure, including those who were not originally in the database. Although the patients in our study function as their own comparison group to support our conclusion that the Drey standards are more consistent with our preoperative GA assessment than Streeter standards, we cannot generalize this conclusion to other patient populations.

Increasing legal restrictions have placed additional burden on clinicians to provide abortions without placing themselves in legal jeopardy or unnecessarily limiting access. Being transparent and consistent with preoperative and postoperative dating procedures is important, but having an updated standard universally accepted by abortion providers and gynecologic pathologists is critical to our goal of safe and legal abortion provision. Abortion providers in institutions and clinics that require formal pathology

Table 3
Relation of measured to expected fetal foot length using Drey pathology standards in women undergoing second-trimester surgical abortion[a] [8]a, b

Preoperative GA (weeks)[b]	Number	Smaller	Concordant	Larger
14 to 17-6/7	139	25 (18.0)	111 (79.9)	3 (2.1)
18 to 18-6/7	56	10 (18.9)	46 (82.1)	0
19 to 19-6/7	62	20 (32.3)	39 (62.9)	3 (4.8)
20 to 20-6/7	64	4 (6.3)	57 (89.0)	3 (4.7)
21 to 21-6/7	62	7 (11.3)	49 (79.0)	6 (9.7)
22 to 22-6/7	47	10 (21.3)	35 (74.5)	2 (4.2)
23 to 23-6/7	39	6 (15.4)	33 (84.6)	0
Total	469	82 (17.5)	370 (78.9)	17 (3.6)

All data presented as *n* (%).

[a] Drey defines a minimum and maximum foot length with 1 SD for each gestational age week. "Concordant" indicates patients whose measured fetal foot length fell within 1 SD of the minimum and maximum lengths for that GA week, "larger" are those whose foot lengths were larger than 1 SD of the maximum, and "smaller" are those whose fetal foot lengths were 1 SD smaller than the minimum.

[b] Preoperative gestational age was based on LMP or sonographic dating in cases of unknown LMP or when the discrepancy between sonographic and LMP dating exceeded 7 days (<15-6/7 weeks' GA), 10 days (16 to 21-6/7 weeks' GA) or 14 days (22 to 23-6/7 weeks' GA) [5].

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evaluation should work closely with their pathologists to determine which fetal measurement standard to use, but based on our findings, we recommend abandoning Streeter standards in contemporary medical practice.

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